Quality Assurance Methods for Fiber Reinforced Composites

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INTRODUCTION

General aviation has primarily dominated the recent growth of new composite aircraft and composite material applications in primary structures. Figure (1) shows several new composite aircraft undergoing the certification process and evidence exists that many more aircraft are currently undergoing the design and development process that take advantage of composite materials for primary structural applications. With this growth of general aviation composite applications, certifications issues have emerged with respect to the exact philosophy of quality control and assurance methods required and needed to guarantee a safe and consistent material supply.

Figure (1). Current ***composite*** general aviation (FAR part 23) aircraft.

Unlike structural parts that use metallic materials in the manufacturing process, the material properties of composite structures are manufactured into the structure as part of the fabrication process. Therefore, it is essential that material and process specifications used to produce composite materials contain sufficient information to ensure that critical parameters in the fabrication process are identified to facilitate production and adherence to the final engineered part. Due to the wide variety of composite structures now emerging for certification (particularly for general aviation aircraft), control of the materials is rapidly becoming a vital issue with respect to the overall assurance of safety.

OBJECTIVE OF RESEARCH

Figure (2) shows the general cycle of material usage from the development phase to part fabrication. As seen from this figure, a key link in the overall part and/or application success is the material and process specification used for the design. Currently, most general aviation manufacturers are forced to generate material and process specifications that are non-uniform with respect to the requirements placed upon the material vendor (which have been borrowed somewhat from past military applications). These non-uniform material and process specifications then cause the vendor to alter the same material supplied to two different companies in order to meet the companiesí individual specification. This leads to an unstable material supply that must then be retested at the airframe manufacturer to guarantee adherence to the specification and design application. Metallic materials fortunately do not suffer the same fate due to a common specification that was primarily due to the material supply needs of the Second World War.

The following list indicates some of the motivations for the proposed program :

- Lack of a generic material and process specification for most composite materials
- Vendor (material supplier) tests are often repeated by the airframer increasing overall cost
- Some current recommended quality control and assurance test methods (AC 21-26) are non-deterministic and vague
- Weak links exist between quality control, material allowables and material equivalence

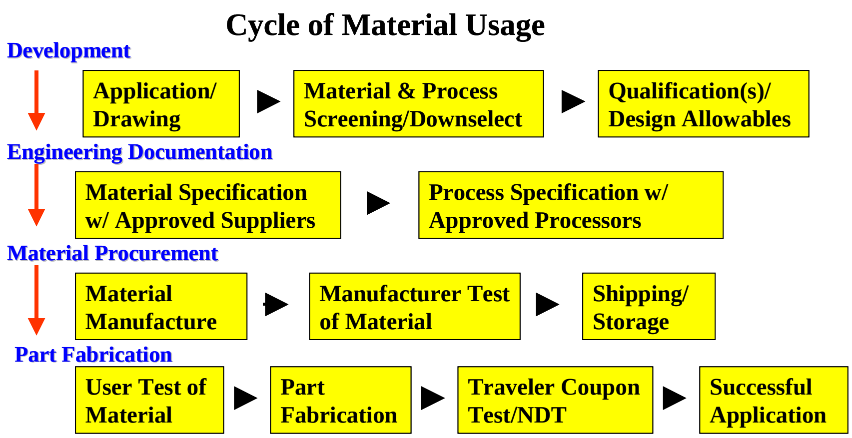

Figure (2). Typical cycle of composite material usage by airframe manufacturer.

TECHNICAL APPROACH

The program was divided into two primary tasks as described below:

TASK 1 ñ COMPOSITE MATERIAL PROCUREMENT AND PROCESS CONTROL SPECIFICATIONS

In recent years, NASA, Industry and the Federal Aviation Administration [FAA] have worked together to develop a cost-effective method of qualifying composite material systems by sharing central material qualification databases such as MIL Handbook-17 and Advanced General Aviation Transport Experiment [AGATE]. Through these shared databases a manufacturer can select an approved composite material system to fabricate parts and perform a smaller subset of testing to a specific application. For materials to be accepted into these shared databases, it is required that all materials be:

> ***manufactured in accordance with a material specification the imposes the key physical, chemical and mechanical properties, and***

processed in accordance with a process specification that adequately control key processing parameters.

Unfortunately, the guidelines for creating the material and process specifications have not been established. The purpose of this task is to assist in standardizing engineering protocol by identifying essential information required for the development of composite (a) material and (b) process specifications, that will be acceptable to material producers, part fabricators, standards development organizations, testing facilities and appropriate regulations. The focus will be on polymer matrix prepreg composite materials such as carbon/graphite and glass

TASK 2 ñ QUALITY ASSURANCE METHODS FOR MATERIAL CONTROL

This second task will focus on ways in which the quality assurance and material control can possibly be changed to a simpler procedure which aides the OEM and material supplier and yet provides an assurance of safety. This task will consist of a feasibility study using one or two test methods to assess the detectability of changes in the base material (fiber, resin and/or interface).

The goal of this feasibility study is to provide a level of assurance that if changes are encountered in a material that would typically be detected using traditional methods currently used for quality control, that this new procedure would also detect these changes. The proposed technical approach that will be used for this program will involve using either wet layup or RTM manufactured panels with obvious changes in constituent properties, level of cure, fiber/resin interface, fiber modulus variation, etc. These panels will be ran through typical quality control procedures which are used presently along with the new proposed method. Both methods will be compared qualitatively with each other and with baseline panels in which standard properties would be achieved.

Currently, based upon some industrial guidance and recent approved test plans by at least one general aviation aircraft manufacturer, the proposed test method will involve using a three or four point bend specimen to detect material/process changes and to assess the degree of sensitivity of this proposed method. Based upon the work by Whitney & Husman (1978), this task will also use a flexural test to investigate these changes and assess the degree to which these changes may be identified.

Specifically, the results of the three and four point flexural tests will be compared with the results of conventional quality assurance tests such as tension, compression, in-plane shear and short beam shear. During this feasibility study, we will attempt to answer the following questions:

(1) How well can the proposed test(s) detect changes in key material properties outlined above?
(2) How well do the proposed test(s) compare with existing quality control test methods?
(3) Are the pass/fail criteria such as those in DOT/FAA/AR-00/47 strict enough to detect such material property changes when applied to the proposed tests? Various pass/fail criterion can also be evaluated and compared with others.

(4) If the proposed test(s) are not able to detect all of the key material property changes, what other test should be utilized in combination?

(5) How much labor and equipment saving can be achieved with the use of the proposed test(s)?